

Produced Water Research Portfolio Overview

DOE Upstream Oil and Gas Workshop

Erica Folio

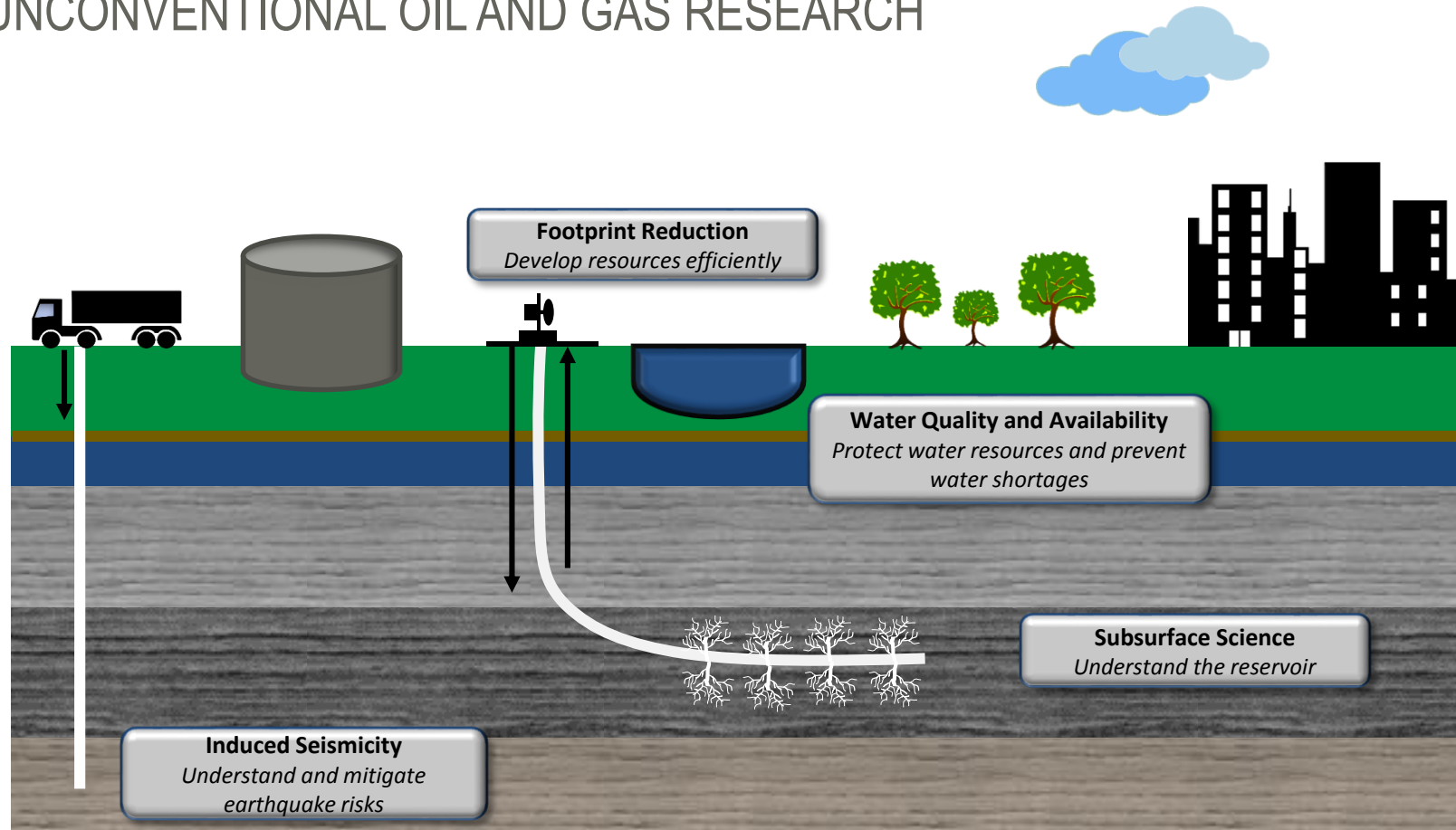
Program Manager, Produced Water

Office of Oil and Natural Gas

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UNCONVENTIONAL OIL AND GAS RESEARCH



Water-related research areas include:

- Reducing freshwater use
- Improving how wells are designed and engineered for zonal isolation
- Handling produced water

PRODUCED WATER PROGRAM OVERVIEW

THE IMPORTANCE

- Treatment and disposal costs > \$40 billion annually
- Advanced, cost-effective technologies lead to beneficial use
- Wastewater injection connected to induced seismicity

THE R&D CHALLENGE

- Complex Treatment Needs
- Variability
- High Volume Disposal
- Cost of Treatment



(Photo courtesy of Energy Corp. of America, from NETL E&P Newsletter 2012)

DOE PRODUCED WATER R&D FOCUS

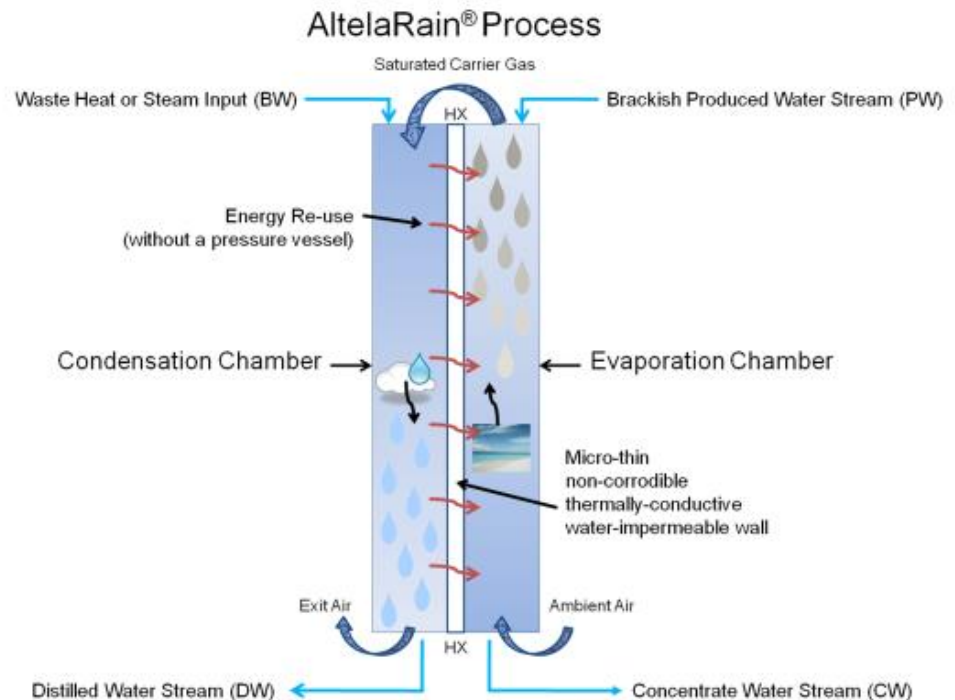
Characterization, Treatment, Management leading to Beneficial Use

Characterization	Publish data; evaluate sampling methods; develop improved practices for sampling and characterization
Treatment	Cost-effective treatment; filtration; physical/chemical separation; coagulation; crystallization
Management	Decision support tools; best practices

PRODUCED WATER TREATMENT

Water Desalination System

- Validated for use in the Marcellus
- Discharge water meets PA requirements
- System field tested then commercialized



PRODUCED WATER MANAGEMENT

Integrated Produced Water Management Framework

- Operators can input site-specific water data
- Generates treatment & management options
- Provides cost information for each option

The screenshot shows the 'START PAGE' of the 'Produced Water Treatment and Beneficial Use Screening Tool'. At the top, there are logos for the Colorado School of Mines, Kennedy/Jenks Consultants, STRATUS CONSULTING, Argonne National Laboratory, and RPSEA (U.S. Department of Energy). On the left, a vertical stack of buttons labeled WQM, TSM, BSM, and BEM is shown. The main content area includes a 'Welcome!' message, a 'Supporting Information' section with links for 'USER MANUAL' and 'TOOL DESCRIPTION', and a 'User Actions' section with a 'Clear all inputs / Restore defaults' button. A 'TOOL ORGANIZATION' diagram shows a flow from 'Water Quality Module (WQM)' to 'Treatment Selection Module (TSM)', then to 'Beneficial Use Screening Module (BSM)', and finally to 'Beneficial Use Economic Module (BEM)'. A large blue arrow points from the text 'To go to the first module click on the start button' to a large blue oval button labeled 'START! (click here)'. A disclaimer at the bottom states that the outputs are for project screening purposes only.

START PAGE

Welcome!

You are now on the start page of the *Produced Water Treatment and Beneficial Use Screening Tool*. This tool will provide you with water quality (based on geographic location), suggest suitable treatment trains to treat that water and provide a cost-benefit analysis of different beneficial reuse options for the water. The *Tool Organization* is shown below. It consists of four modules which should be executed in the order indicated in the figure: Select water quality - Find treatment trains - analyse costs and benefits - perform economic analysis. To move through the tool just click the back and next buttons on each module menu page or click on the module buttons in the header. In each module there will be various user input buttons similar in style to those on the right. Also note that all user input cells are marked in light yellow (also shown to the right). To **get started** click on the **Start Button** in the bottom right corner. Enjoy!

Supporting Information

USER MANUAL Manual for all

TOOL DESCRIPTION Description of the

User Actions

Clear all inputs / Restore defaults Clears all user inputs and restores default values

User input

TOOL ORGANIZATION

Water Quality Module (WQM) → Treatment Selection Module (TSM) → Beneficial Use Screening Module (BSM) → Beneficial Use Economic Module (BEM)

To go to the first module click on the start button

START! (click here)

Disclaimer: The outputs and results obtained from this Integrated Decision Framework are meant for project screening purposes only as relevant information gathered for these modules are based on limited projects and best engineering judgment. Actual projects will contain details not captured in this analysis that may affect the treatment of produced water, regulatory compliance, project feasibility, and overall cost of the project.

SUMMARY

- DOE recognizes the strong relationship between energy and water
- Treatment and management challenges are regional
- Treatment costs can be reduced by matching produced waters with appropriate technology
- Advanced technologies can help produced water become a revenue stream, improving well economics, and, therefore, utilization of domestic shale gas resources

Induced Seismicity Research Portfolio Overview

DOE Upstream Oil and Gas Workshop

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February 14, 2018



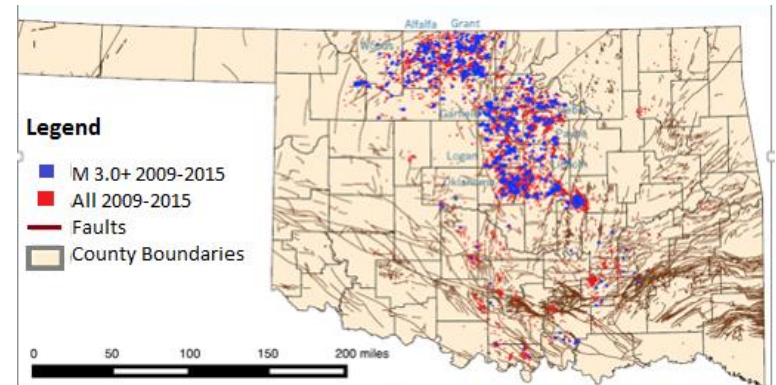
U.S. DEPARTMENT OF
ENERGY

Fossil
Energy

RECENT INDUCED SEISMICITY PROJECTS

University of Oklahoma: *“4D Integrated Study Using Geology, Geophysics, Reservoir Modeling & Rock Mechanics to Develop Assessment Models for Potential Induced Seismicity Risk”*

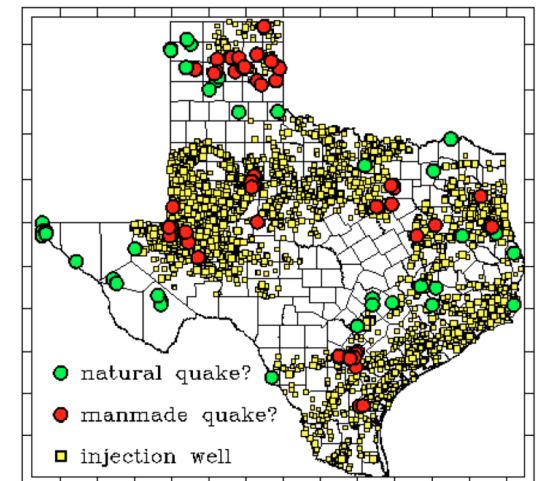
- Increased detection of and improved data record for seismic events in Central Oklahoma
- Added to seismic monitoring stations in Central Oklahoma
- Updated map of basement faults (published by Oklahoma Geologic Survey)



Source: Oklahoma Geological Survey

University of Texas- Austin: *“Relationships between Induced Seismicity and Fluid Injection: Development of strategies to manage fluid disposal in shale plays”*

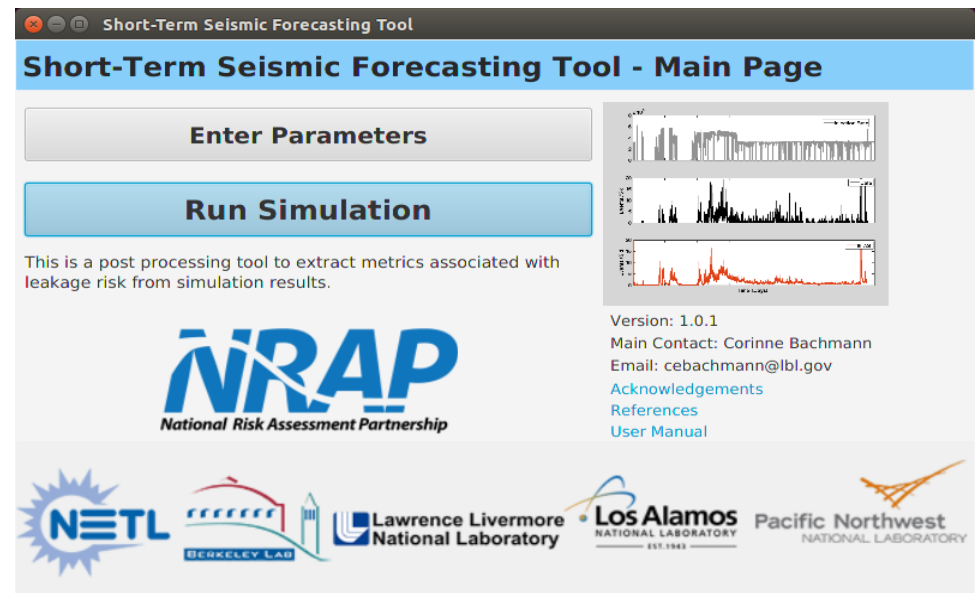
- Conducted two-year surveys of natural and induced seismicity in Fort Worth Basin (TX), Eagle Ford (TX), Bakken/ Williston (ND/MT), and Haynesville (TX/LA)
- Concluded that the injection/seismicity relationship is different in different regions. For example, induced seismicity in the:
 - Fort Worth Basin is associated with injection wells
 - Eagle Ford area is associated with extraction



Source: University of Texas

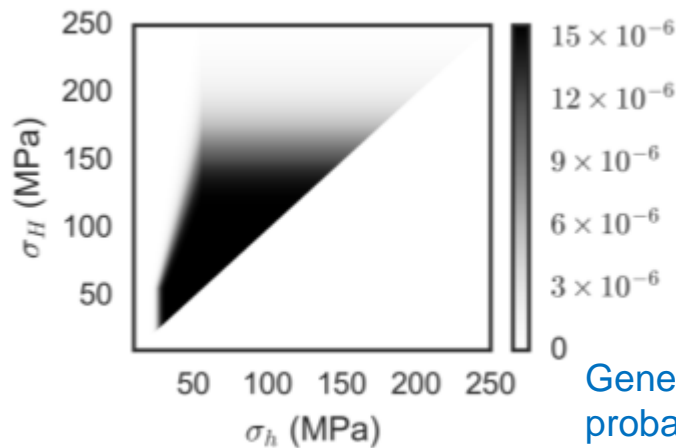
- Forecasts seismic event frequency over the short term
- Potential to complement stoplight approach for induced seismicity planning and permitting

- Based on Gutenberg and Omori laws
- Originally an aftershock model
- Reads a seismic event catalog and incorporates basic injection information
- Forecasts seismic frequency for a window of a few days

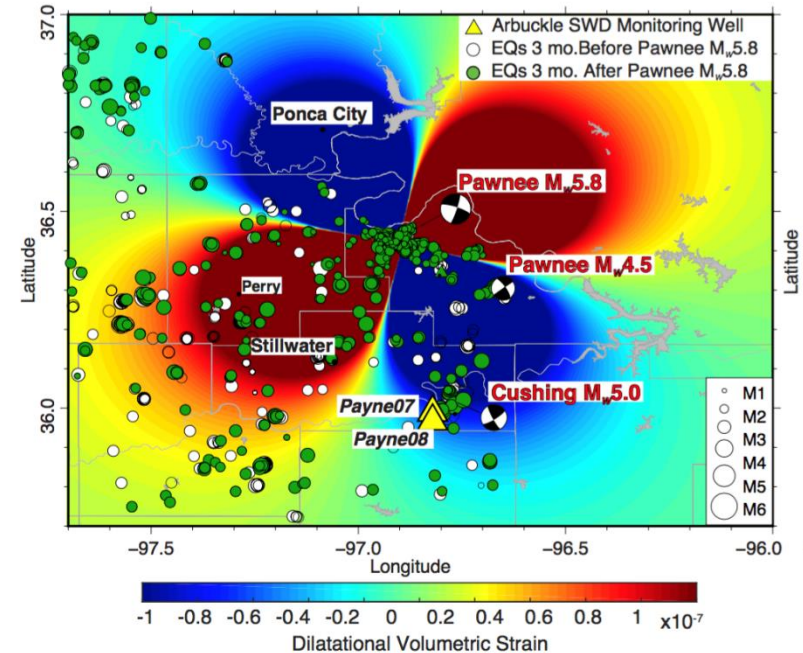


NRAP POC: Josh White, Corinne Bachman (LLNL)

- Real-time hazard forecasting
- Active seismicity management
- Probabilistic seismic risk assessment
- Fault leakage
- Seismicity management protocols

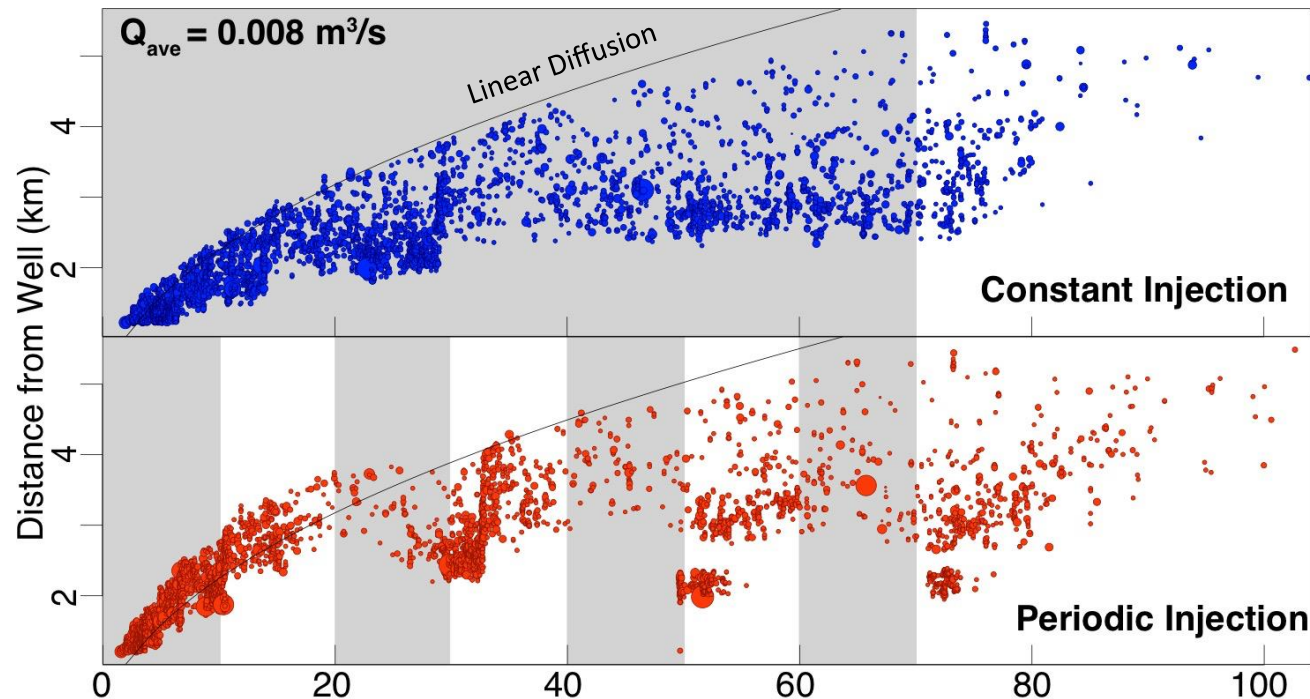


Generating stress polygon to use for probabilistic assessment of fault reactivation potential



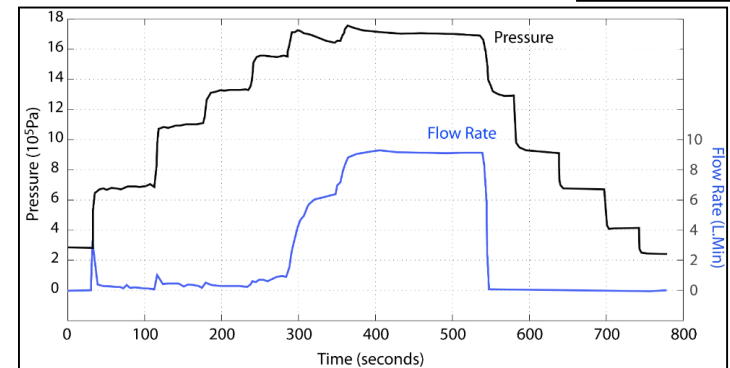
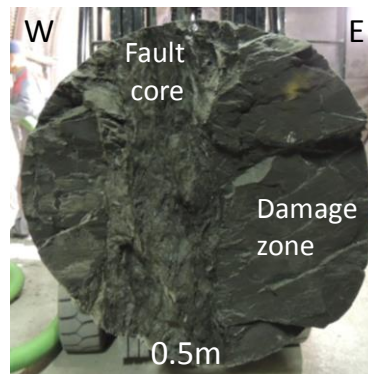
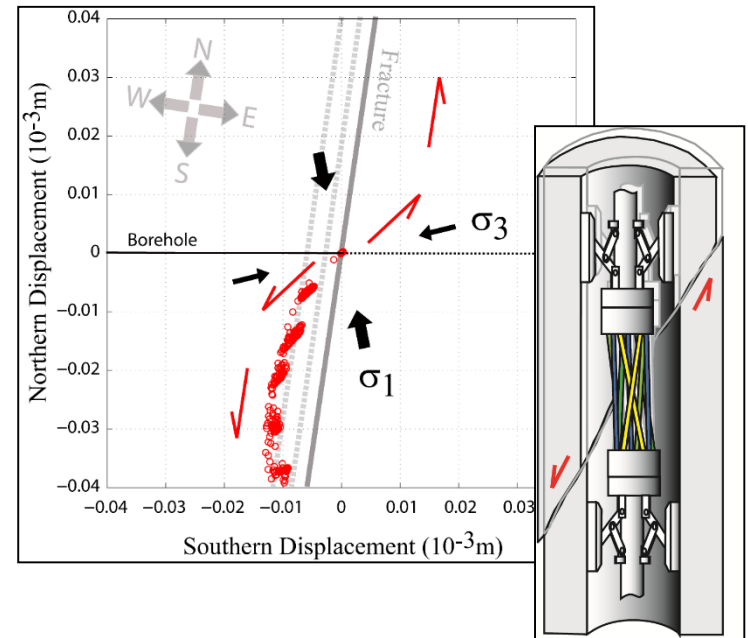
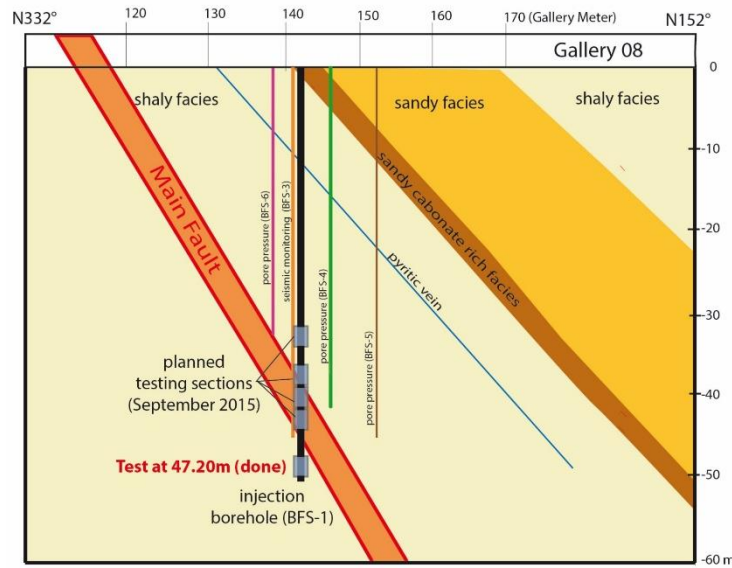
Use data and simulations to characterize formation mechanical and hydraulic properties

Determine effectiveness of different techniques (e.g. pressure control) for managing seismicity at problematic sites.



INDUCED SEISMICITY TESTING IN MONT TERRI URL

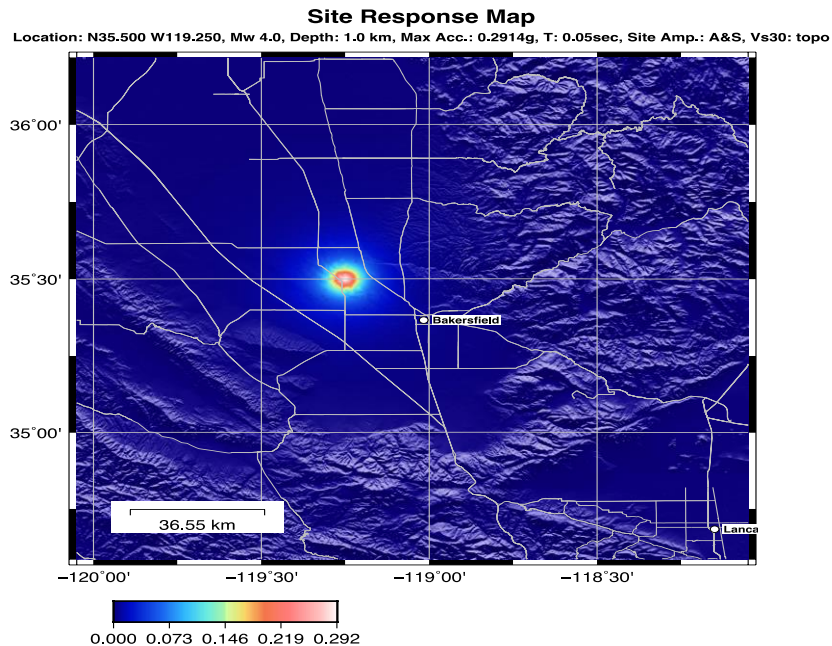
- Tunnel-based access allows for detailed analysis of fault characteristics, easy access to cores, packer testing of fault zones, etc.
- Fault analysis and testing has been conducted by Mont Terri Consortium, with partial funding by DOE FE



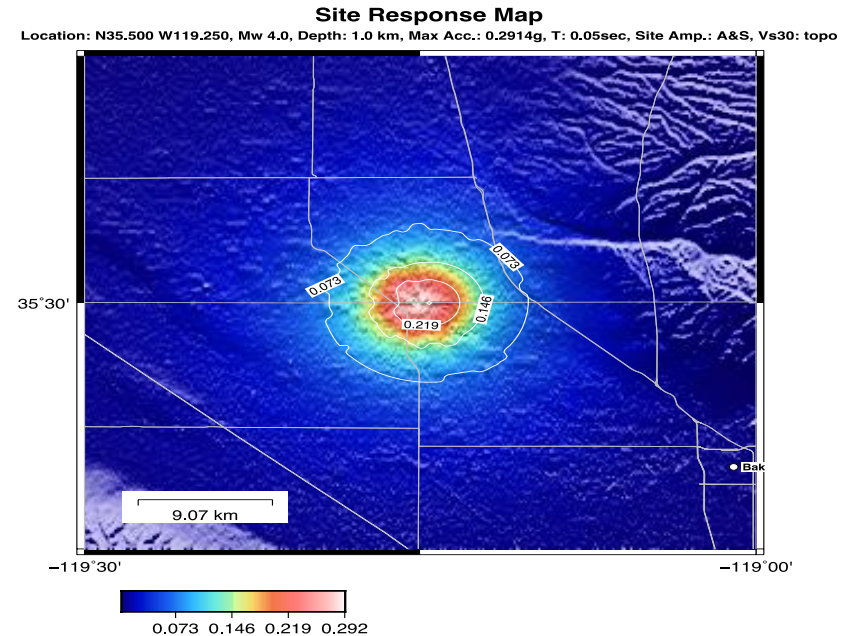
SUMMARY

- Having good field data is a key to proactively addressing induced seismicity
- DOE labs have capabilities to address induced seismicity issues
- Some tools have been recently developed and are available for use
 - Forecast near-term seismic events
 - Estimate risk to surface facilities
- Geomechanical and flow modeling, combined with field measurements, can help manage risk of induced seismicity

MEDIAN GROUND MOTIONS PREDICTED FOR HYPOTHETICAL MW 4.0 EARTHQUAKE



Map of Site response from an induced event In San Joaquin Valley

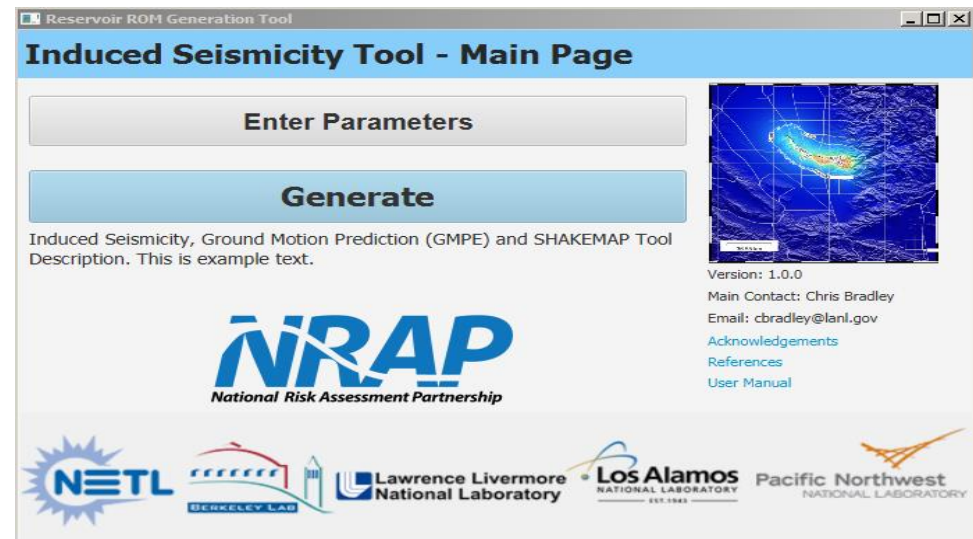


Large Scale Map of Site response showing the detail accelerations in Kimberlina area

NOTE: Hypothetical case for demonstration purposes only

- Ground motion prediction from potential induced earthquakes based on global dataset
- Tectonic scenario earthquakes could provide a valuable planning tool due to potential of injection to stimulate the rate of natural seismicity

- Two approaches to characterizing ground motion: peak ground acceleration (PGA) and peak ground velocity (PGV)
- Database includes induced seismicity (IS) from global active geothermal locations producing nearly 4,000 records
- Implements IS empirical ground motion prediction equations (Douglas et al., 2013)
- Applicable for cases where little site-specific seismic data are available
- Incorporates published models for site-specific amplification corrections (Boore and Atkinson, 2008; Abrahamson and Silva, 2008).



NRAP POC: Chris Bradley (LANL)